Quick Tour of Microsoft Excel Solver

Month	*Q1*	*Q2*	*Q3*	*Q4*	*Total*
Seasonality	0.9	1.1	0.8	1.2	
Units Sold	3,592	4,390	3,192	4,789	15,962
Sales Revenue	$143,662	$175,587	$127,700	$191,549	$638,498
Cost of Sales	89,789	109,742	79,812	119,718	399,061
Gross Margin	53,873	65,845	47,887	71,831	239,437
Salesforce	8,000	8,000	9,000	9,000	34,000
Advertising	10,000	10,000	10,000	10,000	40,000
Corp Overhead	21,549	26,338	19,155	28,732	95,775
Total Costs	39,549	44,338	38,155	47,732	169,775
Prod. Profit	$14,324	$21,507	$9,732	$24,099	$69,662
Profit Margin	10%	12%	8%	13%	11%

Color Coding

Target cell

Changing cells

Constraints

Product Price	$40.00
Product Cost	$25.00

The following examples show you how to work with the model above to solve for one value or several values to maximize or minimize another value, enter and change constraints, and save a problem model.

Row	Contains	Explanation
3	Fixed values	Seasonality factor: sales are higher in quarters 2 and 4, and lower in quarters 1 and 3.
5	=35*B3*(B11+3000)^0.5	Forecast for units sold each quarter: row 3 contains the seasonality factor; row 11 contains the cost of advertising.
6	=B5*B18	Sales revenue: forecast for units sold (row 5) times price (cell B18).
7	=B5*B19	Cost of sales: forecast for units sold (row 5) times product cost (cell B19).
8	=B6-B7	Gross margin: sales revenues (row 6) minus cost of sales (row 7).
10	Fixed values	Sales personnel expenses.
11	Fixed values	Advertising budget (about 6.3% of sales).
12	=0.15*B6	Corporate overhead expenses: sales revenues (row 6) times 15%.
13	=SUM(B10:B12)	Total costs: sales personnel expenses (row 10) plus advertising (row 11) plus overhead (row 12).
15	=B8-B13	Product profit: gross margin (row 8) minus total costs (row 13).
16	=B15/B6	Profit margin: profit (row 15) divided by sales revenue (row 6).
18	Fixed values	Product price.
19	Fixed values	Product cost.

This is a typical marketing model that shows sales rising from a base figure (perhaps due to the sales personnel) along with increases in advertising, but with diminishing returns. For example, the first $5,000 of advertising in Q1 yields about 1,092 incremental units sold, but the next $5,000 yields only about 775 units more.

You can use Solver to find out whether the advertising budget is too low, and whether advertising should be allocated differently over time to take advantage of the changing seasonality factor.

Solving for a Value to Maximize Another Value

One way you can use Solver is to determine the maximum value of a cell by changing another cell. The two cells must be related through the formulas on the worksheet. If they are not, changing the value in one cell will not change the value in the other cell.

For example, in the sample worksheet, you want to know how much you need to spend on advertising to generate the maximum profit for the first quarter. You are interested in maximizing profit by changing advertising expenditures.

- On the **Tools** menu, click **Solver**. In the **Set target cell** box, type **b15** or select cell B15 (first-quarter profits) on the worksheet. Select the **Max** option. In the **By changing cells** box, type **b11** or select cell B11 (first-quarter advertising) on the worksheet. Click **Solve**.

You will see messages in the status bar as the problem is set up and Solver starts working. After a moment, you'll see a message that Solver has found a solution. Solver finds that Q1 advertising of $17,093 yields the maximum profit $15,093.

- After you examine the results, select **Restore original values** and click **OK** to discard the results and return cell B11 to its former value.

Resetting the Solver Options

If you want to return the options in the **Solver Parameters** dialog box to their original settings so that you can start a new problem, you can click **Reset All**.

Solving for a Value by Changing Several Values

You can also use Solver to solve for several values at once to maximize or minimize another value. For example, you can solve for the advertising budget for each quarter that will result in the best profits for the entire year. Because the seasonality factor in row 3 enters into the calculation of unit sales in row 5 as a multiplier, it seems logical that you should spend more of your advertising budget in Q4 when the sales response is highest, and less in Q3 when the sales response is lowest. Use Solver to determine the best quarterly allocation.

- On the **Tools** menu, click **Solver**. In the **Set target cell** box, type **f15** or select cell F15 (total profits for the year) on the worksheet. Make sure the **Max** option is selected. In the **By changing cells** box, type **b11:e11** or select cells B11:E11 (the advertising budget for each of the four quarters) on the worksheet. Click **Solve**.
- After you examine the results, click **Restore original values** and click **OK** to discard the results and return all cells to their former values.

You've just asked Solver to solve a moderately complex nonlinear optimization problem; that is, to find values for the four unknowns in cells B11 through E11 that will maximize profits. (This is a nonlinear problem because of the exponentiation that occurs in the formulas in row 5). The results of this unconstrained optimization show that you can increase profits for the year to $79,706 if you spend $89,706 in advertising for the full year.

However, most realistic modeling problems have limiting factors that you will want to apply to certain values. These constraints may be applied to the target cell, the changing cells, or any other value that is related to the formulas in these cells.

Adding a Constraint

So far, the budget recovers the advertising cost and generates additional profit, but you're reaching a point of diminishing returns. Because you can never be sure that your model of sales response to advertising will be valid next year (especially at greatly increased spending levels), it doesn't seem prudent to allow unrestricted spending on advertising.

Suppose you want to maintain your original advertising budget of $40,000. Add the constraint to the problem that limits the sum of advertising during the four quarters to $40,000.

- On the **Tools** menu, click **Solver**, and then click **Add**. The **Add Constraint** dialog box appears. In the **Cell reference** box, type **f11** or select cell F11 (advertising total) on the worksheet. Cell F11 must be less than or equal to $40,000. The relationship in the **Constraint** box is **<=** (less than or equal to) by default, so you don't have to change it. In the box next to the relationship, type **40000**. Click **OK**, and then click **Solve**.
- After you examine the results, click **Restore original values** and then click **OK** to discard the results and return the cells to their former values.

The solution found by Solver allocates amounts ranging from $5,117 in Q3 to $15,263 in Q4. Total Profit has increased from $69,662 in the original budget to $71,447, without any increase in the

advertising budget.

Changing a Constraint

When you use Microsoft Excel Solver, you can experiment with slightly different parameters to decide the best solution to a problem. For example, you can change a constraint to see whether the results are better or worse than before. In the sample worksheet, try changing the constraint on advertising dollars to $50,000 to see what that does to total profits.

- On the **Tools** menu, click **Solver**. The constraint, **F11<=40000**, should already be selected in the **Subject to the constraints** box. Click **Change**. In the **Constraint** box, change **40000** to **50000**. Click **OK**, and then click **Solve**. Click **Keep solver solution** and then click **OK** to keep the results that are displayed on the worksheet.

Solver finds an optimal solution that yields a total profit of $74,817. That's an improvement of $3,370 over the last figure of $71,447. In most firms, it's not too difficult to justify an incremental investment of $10,000 that yields an additional $3,370 in profit, or a 33.7% return on investment. This solution also results in profits of $4,889 less than the unconstrained result, but you spend $39,706 less to get there.

Saving a Problem Model

When you click **Save** on the **File** menu, the last selections you made in the **Solver Parameters** dialog box are attached to the worksheet and retained when you save the workbook. However, you can define more than one problem for a worksheet by saving them individually using **Save Model** in the **Solver Options** dialog box. Each problem model consists of cells and constraints that you entered in the **Solver Parameters** dialog box.

When you click **Save Model**, the **Save Model** dialog box appears with a default selection, based on the active cell, as the area for saving the model. The suggested range includes a cell for each constraint plus three additional cells. Make sure that this cell range is an empty range on the worksheet.

- On the **Tools** menu, click **Solver**, and then click **Options**. Click **Save Model**. In the **Select model area** box, type **h15:h18** or select cells H15:H18 on the worksheet. Click **OK**.

Note You can also enter a reference to a single cell in the **Select model area** box. Solver will use this reference as the upper-left corner of the range into which it will copy the problem specifications.

To load these problem specifications later, click **Load Model** on the **Solver Options** dialog box, type **h15:h18** in the **Model area** box or select cells H15:H18 on the sample worksheet, and then click **OK**. Solver displays a message asking if you want to reset the current Solver option settings with the settings for the model you are loading. Click **OK** to proceed.